Overview of Groundfish Assessments

Theme I
Agenda Item 4.0

NOAA FISHERIES

Southwest Fisheries Science Center

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Fisheries Ecology Division

29 July 2014

Assessment of West Coast Groundfish

- Groundfish research at the SWFSC prioritizes science in support of management
  - Conduct stock assessments
  - Basic research: population dynamics, reproductive biology, ageing, etc.
  - Collect, recover, and analyze data critical to assessments
- Assessment Terms of Reference (TOR) links analytical framework to available information (types of data)

Category	Data	Framework Examples
Data-poor (cat. 3)	catch, life history	DCAC, DB-SRA, SSS
Data-moderate (cat. 2)	+ abundance trend, or survey biomass	XDB-SRA, ex-SSS, SS, F_{MSY} × Survey Biomass
Data-rich (cat. 1)	+ age/size composition	Stock Synthesis (SS)

Scientific/technical approach to fishery stock assessment modeling

- Models for sustainable yield in data-limited situations ("data-poor" stocks)
- Stock assessments
  - Data-moderate
  - Data-rich
  - Rebuilding analyses
- Related Research

Data-poor Models

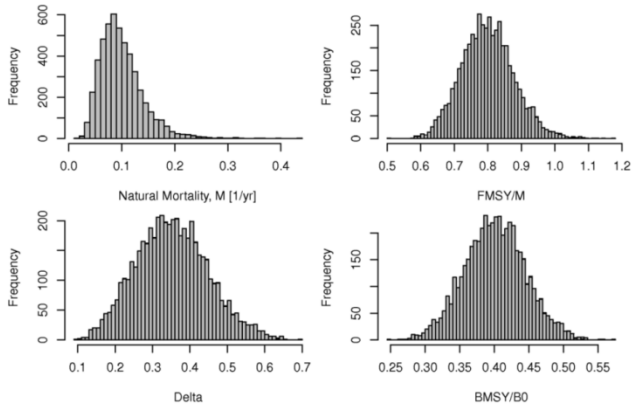
Background: Meeting the ACL Requirement for West Coast Groundfish

- Reauthorized Magnuson-Stevens Act (2006): Establish Annual Catch Limits (ACLs) by 2011
- 90+ species in PFMC's Groundfish FMP
- 30 species assessed from 1982-2009
- Data-poor methods in use as of 2009:
  - Average or maximum catch (undocumented)
  - F x Survey Biomass
  - Precautionary reductions, assumed status (Restrepo et al., 1998)
  - Productivity-Susceptibility Analysis (Patrick et al., 2009)

Depletion-Corrected Average Catch (DCAC; MacCall 2009)

- Sustainable Yield Calculated as:

$$Harvest = \frac{\sum Catch}{n + \left(\frac{\Delta}{\frac{B_{MSY}}{B_0} * \frac{F_{MSY}}{M} * M} \right)}$$



where:

n is the number of years,

Δ is the relative stock status to starting conditions (Δ = reduction in biomass; units of B_0),

$BMSY/B0$ is the relative stock size where maximum sustainable yield (MSY) occurs,

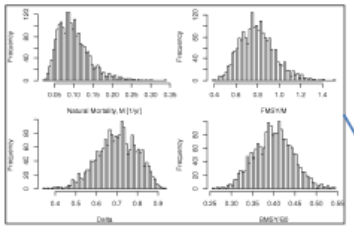
M is natural mortality, and

$FMSY/M$ is the ratio of the fishing mortality rate associated with MSY and natural mortality.

Important Contributions to "Data-Poor" Efforts

- Commercial & Recreational Catch Reconstructions
  - CA: "Off-year" workshop (SWFSC / CDFW)
    - ➢ Commercial groundfish catch, by species since 1916
    - ➢ Recreational rockfish catch, by species, since 1928
  - OR: commercial reconstruction (NWFSC / ODFW)
    - ➢ Commercial groundfish catch, by species, since late 1800s
    - ➢ No recreational reconstruction prior to 1980
  - WA: still pending
- PSA analysis for stock complexes (GMT, 2009; Cope et al., 2011)

Depletion-Based Stock Reduction Analysis (DB-SRA)



Age at maturity

Catch by year

Population Model

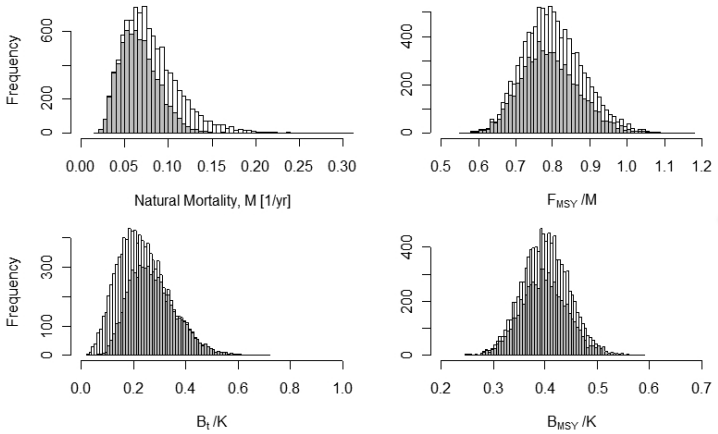
$$B_{t+1} = B_t + P_{t-a} - C_t$$

B_0

OFL

MSY

B_{MSY}



Dick and MacCall 2010. Dick and MacCall 2011

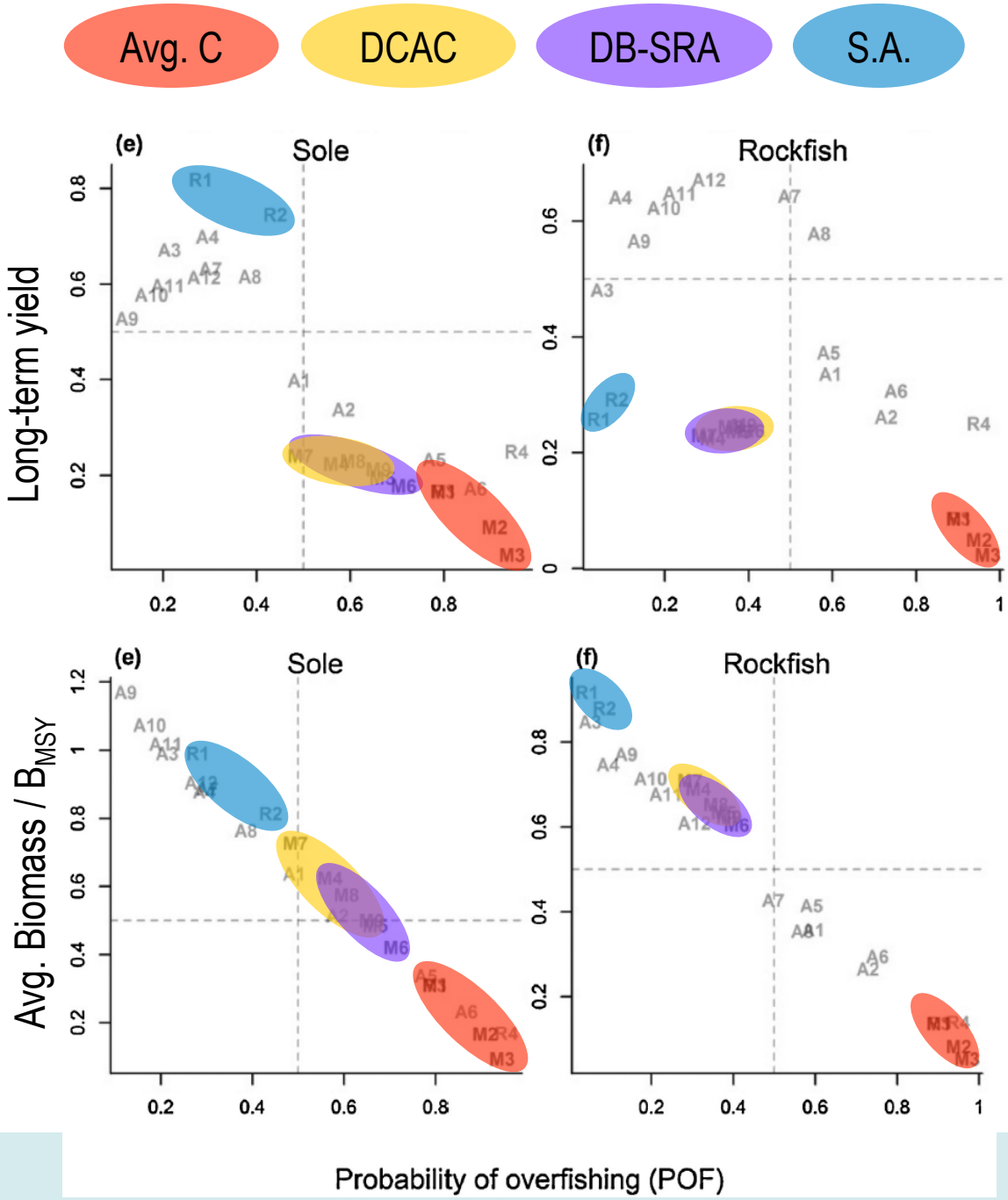
PFMC Implementation of Data-Poor Methods

- Jan. 2010: DB-SRA and DCAC reviewed and endorsed by Groundfish Subcommittee of SSC
- March 2010: Presented results for 50 data-poor stocks to SSC
- April 2010: PFMC adopted results as basis for OFLs in 2011-12 harvest specifications

MSE: Performance of Data-Limited Models, "Overfished" stocks (<50% B_{MSY})

- Relative to average catch method, DCAC and DB-SRA reduce the probability of overfishing, while increasing or maintaining long-term yield
- Dynamic methods further improve performance (e.g. XDB-SRA & ex-SSS)

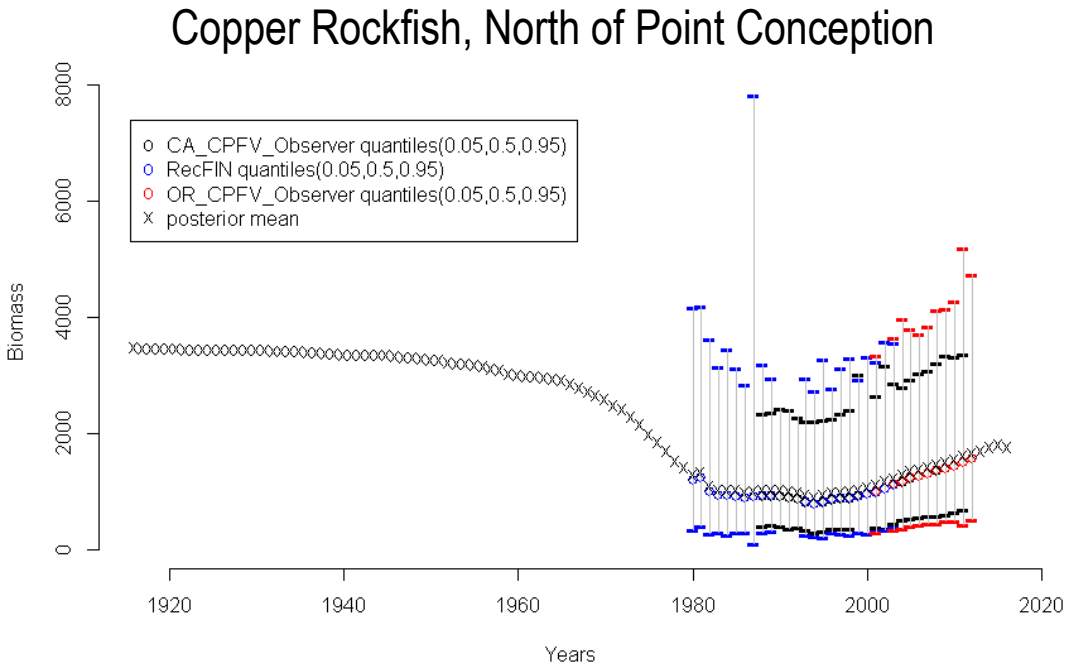
Carruthers et al. 2014, Fish. Res.

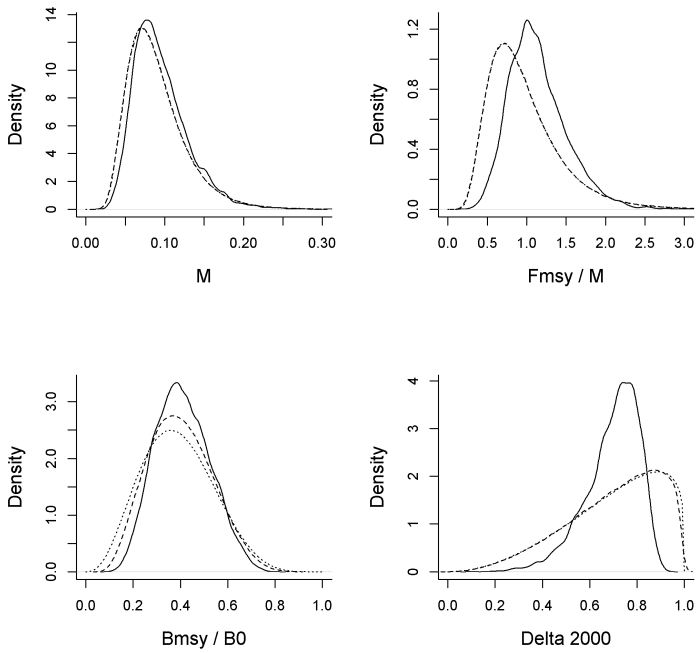


Data-Moderate Assessments

Extended Depletion-Based Stock Reduction Analysis (XDB-SRA)

- DB-SRA uses catch, age-at-maturity, and prior distributions; results are “prior predictive distributions”
- Given an index of abundance (absolute or relative) and likelihood function, DB-SRA becomes a Bayesian model (XDB-SRA)



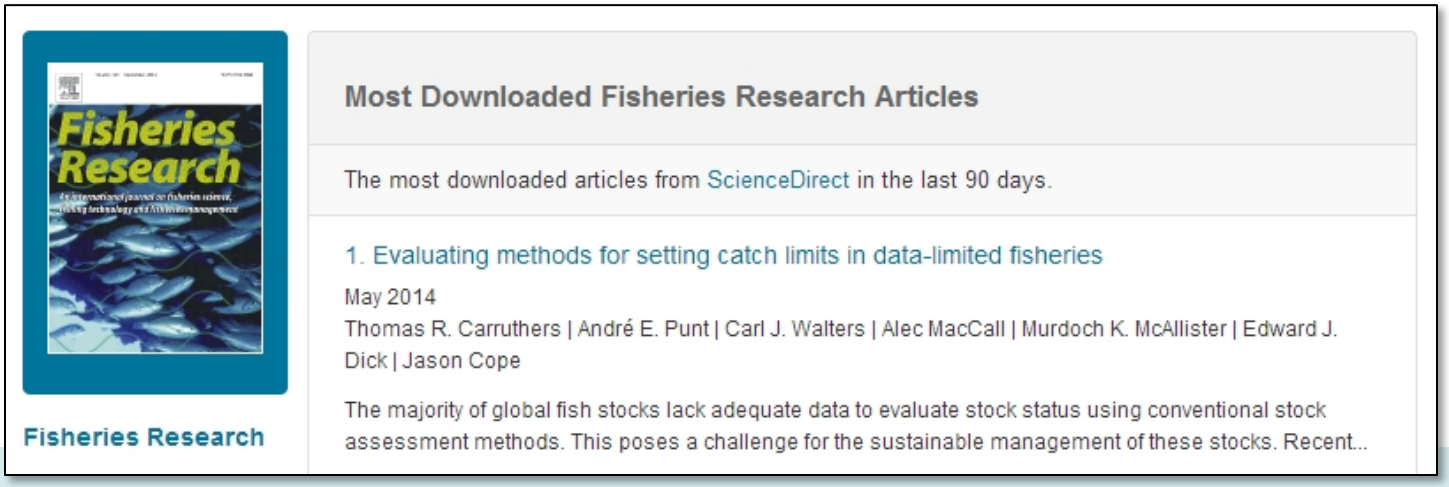


Extended Depletion-Based Stock Reduction Analysis (XDB-SRA)

- XDB-SRA and ex-SSS reviewed by methodology review panel ("Assessment Methods for Data-Moderate Stocks") in June 2012
- Designed to produce "category 2" stock assessments
  - "Promote" data-poor stocks by using simple models and data (estimate status, rather than assume)
  - Increase throughput of assessments
- Data-moderate assessments completed for 6 stocks in 2013-14 cycle
  - XDB-SRA: Brown, China, and Copper rockfishes
  - ex-SSS: Rex sole, Sharpchin rockfish, Stripetail rockfish

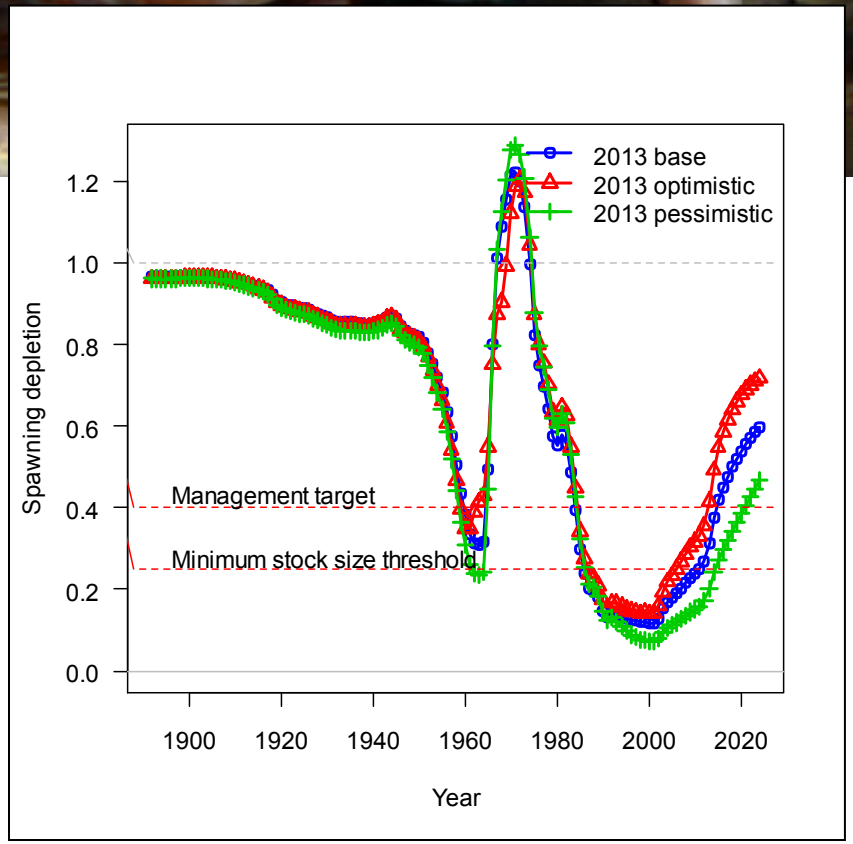
Impact of Data-Limited Methods

- DB-SRA and DCAC
  - Met 2011 ACL requirement for West Coast groundfish
  - Default models for PFMC data-poor stocks (applied to 40+ species) since 2011
  - Code frequently requested, made freely available
- XDB-SRA & ex-SSS
  - Six data-moderate assessments reviewed and approved for 2015-16 cycle
  - “Full” assessment of cowcod (*S. levis*) based on XDB-SRA model



Data-Rich Assessments

Bocaccio (*Sebastes paucispinis*)



- Declared overfished in 1999
- Length-based, age-structured model
- Fit to indices of abundance and length composition data
- Spawning output at ~31% of unfished level in 2013

Stock Synthesis (Methot and Wetzel, 2013)

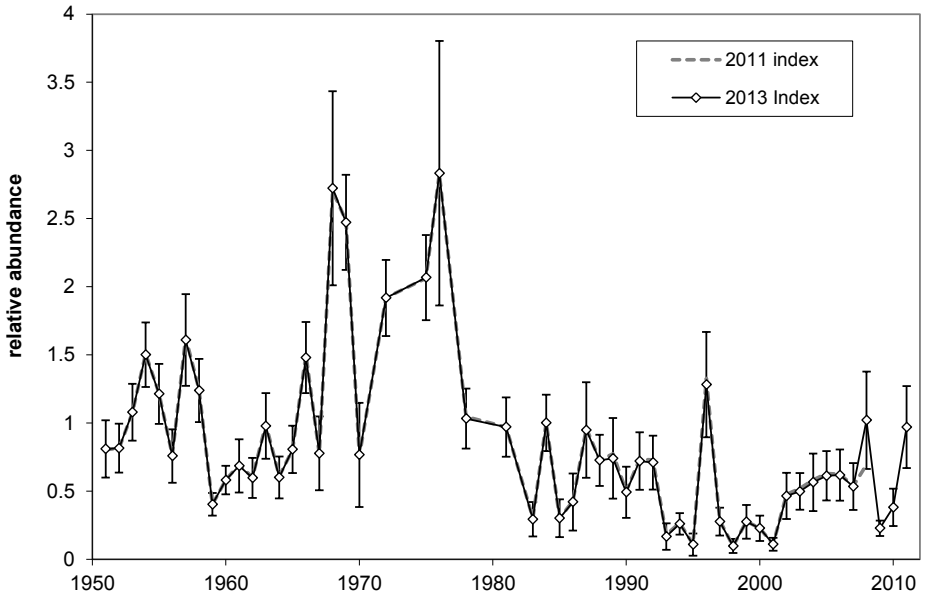
- Primary model for "data-rich" groundfish assessments
- Statistical age-structured population modeling framework
- Common platform → efficient development, collaboration, and review

Features and data types include:

- **Multiple fleets & areas**
- **Parameter estimation: SRR, recruitment deviations, growth, M, selectivity, discard, retention, catchability, initial equilibrium F.**
- **Time-varying parameters**
- **Abundance indices**
- **Composition data (ages, lengths, and/or conditional age@length)**
- **Efficient optimization (ADMB)**
- **Parameter uncertainty: asymptotic SE, likelihood profile, and MCMC.**
- **Possible to incorporate environmental indices**

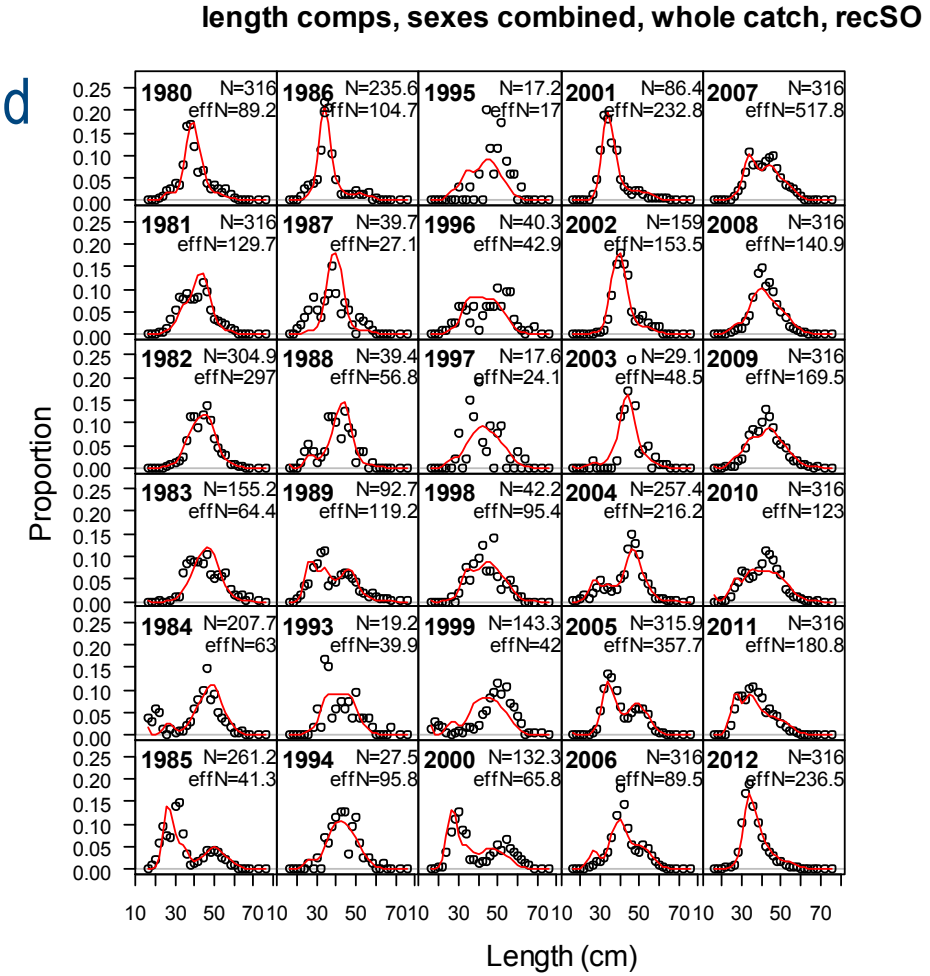
Bocaccio: Indices of Abundance

- CalCOFI larval abundance (SWFSC, SIO, CDFW) 1951-ongoing
- SWFSC YOY rockfish survey 2003-ongoing
- NWFSC trawl survey 2003-ongoing
- NWFSC hook and line survey 2004-ongoing
- Recreational CPUE (3 indices) 1980-2002
- Power plant impingement survey 1972-ongoing
- AFSC / NWFSC Triennial survey 1980-2004



Bocaccio: Length Composition Data

- Evidence of highly variable and episodic recruitment
- "When lengths are better than ages: The complex case of bocaccio" (Ralston and Ianelli, 1998)
- Data sources include:
  - Commercial catch-at-length
  - Recreational catch-at-length
  - NWFSC Trawl Survey
  - NWFSC Hook and Line Survey



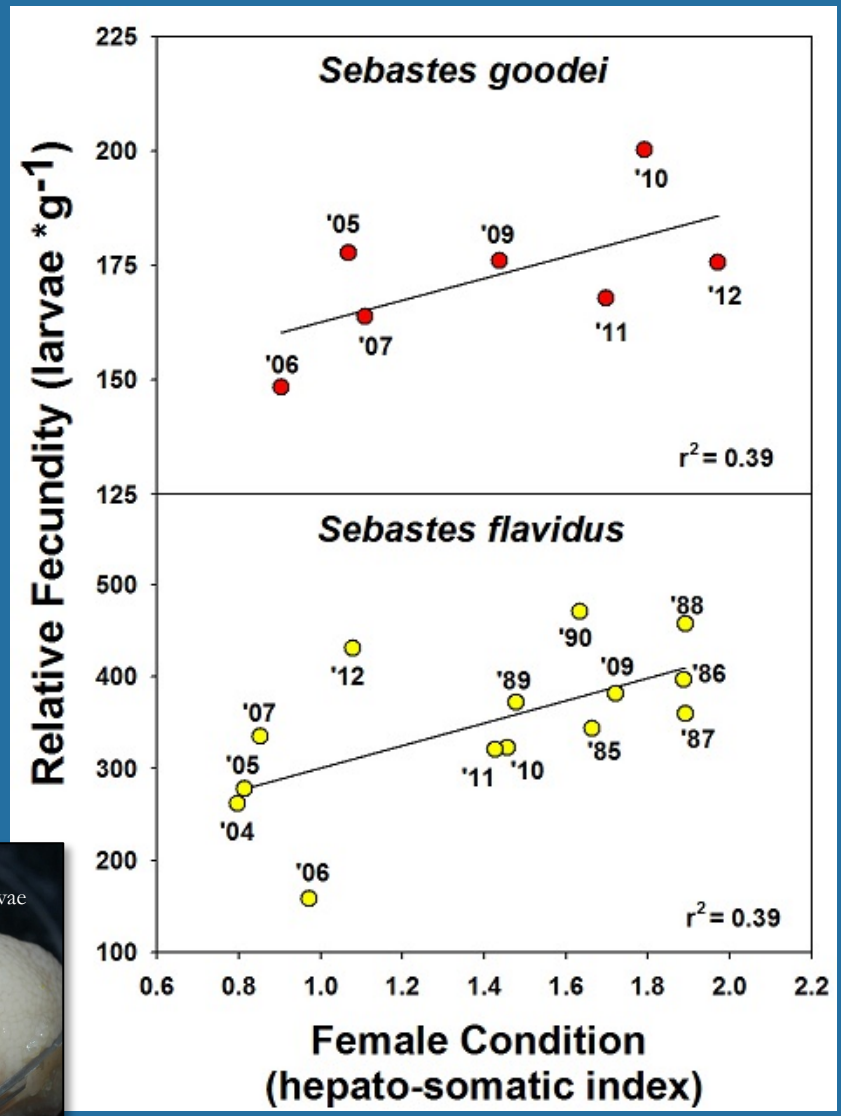
Bocaccio: Ongoing research

- Ages!
  - New ageing criterion
  - Integrated digital microscope
  - Production ageing underway
- Regional Recreational CPUE (trip level)
- Reproductive biology (multiple broods)

Environmental Effects on Female Condition and Egg Production

- Recent and historical data suggest that a decline in female condition, often associated with poor ocean conditions (e.g., El Niño), results in years of decreased egg production.
- Multiple broods have also been known to occur during favorable environmental conditions, particularly in southern regions, but never truly considered in assessments.
- We are quantifying and validating fecundity and multiple brooding (latter using histological as well as macroscopic methods), to evaluate impacts of variable larval production on productivity.

Large female Bocaccio with fertilized eggs



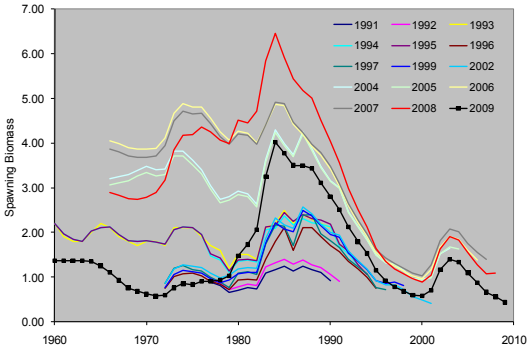
Rebuilding Analyses

- SSC default rebuilding analysis software, aka the “Puntalizer” (A. Punt, Univ. of Washington)
  a) Determine the maximum allowable rebuilding period.
  b) Determine the (generally constant) level of fishing mortality (or catch) that satisfies specifications regarding the probability of recovery within the maximum allowable rebuilding period.
  c) Conduct projections for various user-specified time-trajectories of fishing mortality, spawning potential ratio or of catch (harvest strategies) to evaluate the trade-off between the annual catches and the rate of recovery to the target biomass.
  d) Display various output statistics.
- Accepts standardized input from age-structured models (e.g. SS)
- Projections able to propagate uncertainty in recruitment and parameter uncertainty

Assessment-Related Research

Groundfish Stock Assessment Tiers

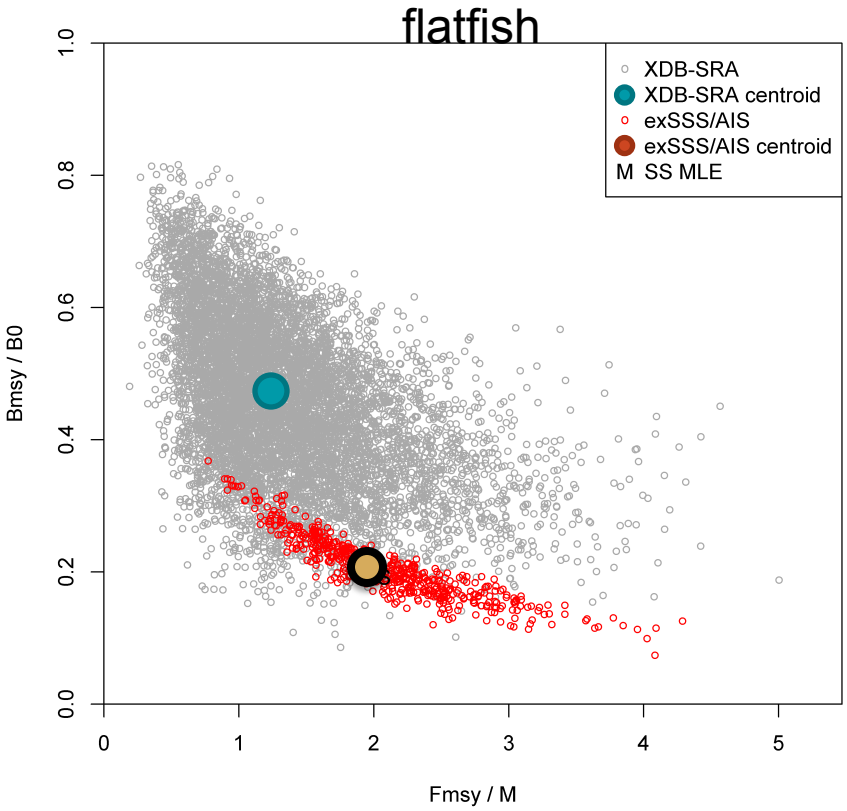
Meta-analysis by Ralston et al. (2011) is scientific basis for ABC buffers

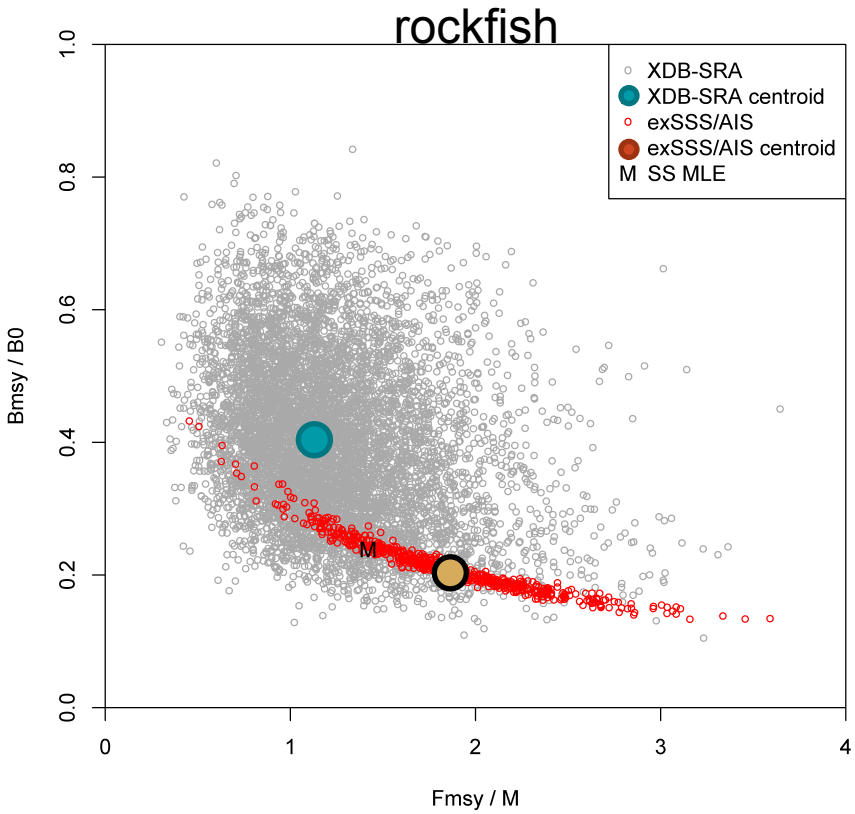


Category 3: Data poor. OFL is derived from historical catch. $\sigma = 1.44$	**a**	No reliable catch history. No basis for establishing OFL.
	b	Reliable catches estimates only for recent years. OFL is average catch during a period when stock is considered to be stable and close to BMSY equilibrium on the basis of expert judgment.
	c	Reliable aggregate catches during period of fishery development and approximate values for natural mortality. Default analytical approach DCAC.
	d	Reliable annual historical catches and approximate values for natural mortality and age at 50% maturity. Default analytical approach DB-SRA.
Category 2: Data moderate. OFL is derived from model output (or natural mortality). $\sigma = 0.72$	**a**	M*survey biomass assessment (as in Rogers 1996).
	b	Historical catches, fishery-dependent trend information only. An aggregate population model is fit to the available information.
	c	Historical catches, survey trend information, or at least one absolute abundance estimate. An aggregate population model is fit to the available information.
	d	Full age-structured assessment, but results are substantially more uncertain than assessments used in the calculation of the P* buffer. The SSC will provide a rationale for each stock placed in this category. Reasons could include that assessment results are very sensitive to model and data assumptions, or that the assessment has not been updated for many years.
Category 1: Data rich. OFL is based on F_{MSY} or F_{MSY} proxy from model output. ABC based on P* buffer. $\sigma = 0.36$	**a**	Reliable compositional (age and/or size) data sufficient to resolve year-class strength and growth characteristics. Only fishery-dependent trend information available. Age/size structured assessment model.
	b	As in 1a, but trend information also available from surveys. Age/size structured assessment model.
	c	Age/size structured assessment model with reliable estimation of the stock-recruit relationship.

Implicit Productivity Assumptions in Stock-Recruitment Relationships

- Productivity parameters in 2-parameter SRRs determine management reference points (Mangel et al., 2013, CJFAS)
- Data support regions inaccessible to Beverton-Holt SRR





Environmental and Ecosystem Effects

- Reproductive biology
  - Fecundity (weight-specific) and age/size at maturity
  - Multiple broods
  - Spatial and temporal variation in fecundity
- "Dynamic B_0"
  - Sardine (MacCall, 1979), Mackerel (MacCall et al. 1985)
  - Shortbelly rockfish assessment (Field et al., 2007); traditional assessment of unexploited stock
  - Measuring impact of fisheries on seabird populations (Field et al., 2010)

Understanding Historical Catches

Estimating species composition and quantifying uncertainty in multispecies fisheries: hierarchical Bayesian models for stratified sampling protocols with missing data

Andrew O. Shelton, E.J. Dick, Donald E. Pearson, Stephen Ralston, and Marc Mangel

OPEN ACCESS Freely available online

PLOS ONE

A Spatially Distinct History of the Development of California Groundfish Fisheries

Rebecca R. Miller[1,2]*, John C. Field[2], Jarrod A. Santora[3], Isaac D. Schroeder[4], David D. Huff[1], Meisha Key[5], Don E. Pearson[2], Alec D. MacCall[2]

SEPTEMBER 2013

DOCUMENTATION OF THE
CALIFORNIA CATCH RECONSTRUCTION PROJECT

Stephen Ralston
Donald E. Pearson
John C. Field
Meisha Key

DOCUMENTATION
FOR THE ORE
ONBOARD

NOAA Technical Memorandum NMFS

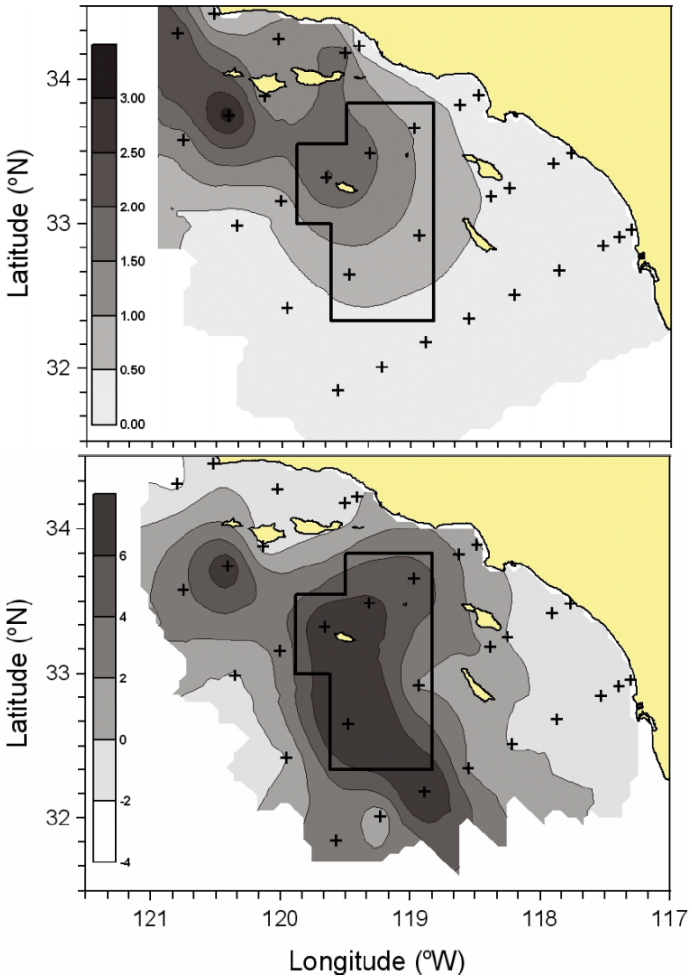
JULY 2014

DOCUMENTATION OF A RELATIONAL DATABASE FOR THE CALIFORNIA RECREATIONAL FISHERIES SURVEY ONBOARD OBSERVER SAMPLING PROGRAM, 1999-2011

[1,2]Melissa Monk
[2]E. J. Dick
[2]Don Pearson

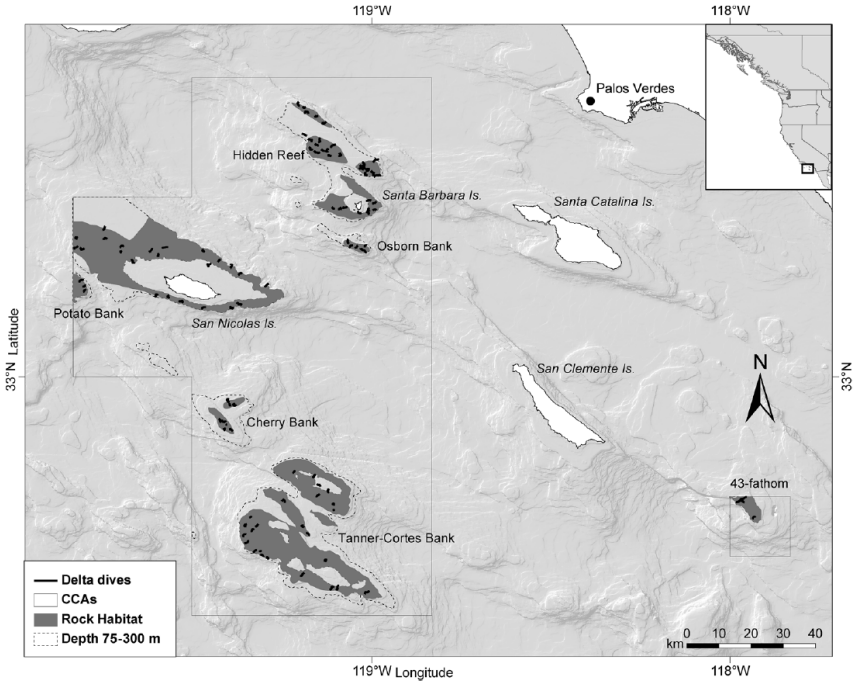
Recruitment Trends and Larval Abundance

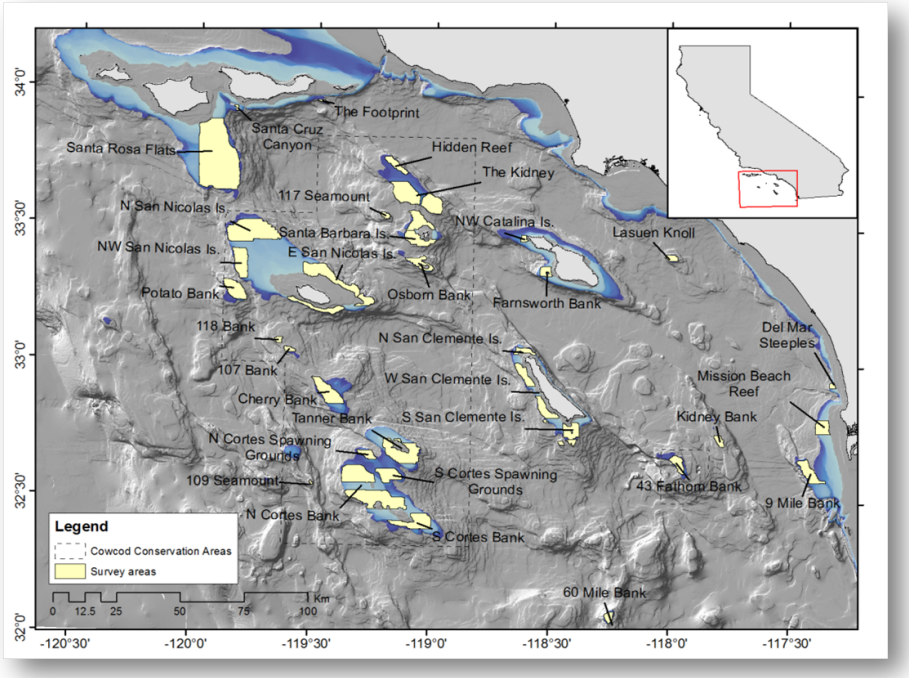
- Rockfish Recruitment and Ecosystem Assessment Survey
  - 1983 – present (core area); coastwide since 2003
  - Indices of year class strength; evaluation of environmental covariates
- CalCOFI
  - Larval abundance (spawning output) over time (e.g. bocaccio and cowcod)
  - Spatial distribution of mature biomass (Ralston and MacFarlane, 2010)
  - Genetic identification of larvae
  - Annual sampling in CCAs



Visual Surveys for Absolute Abundance

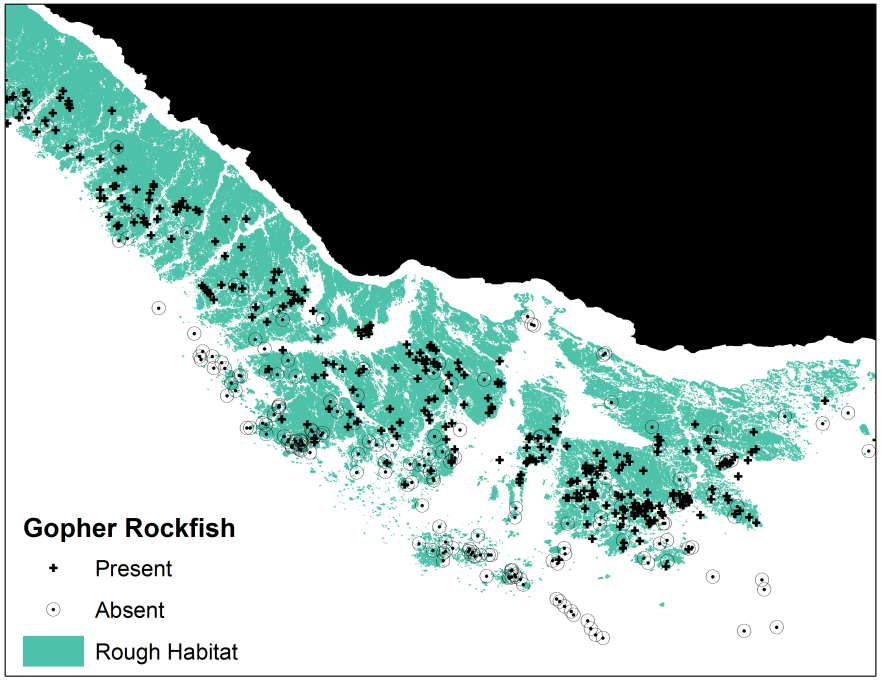
- Submersible (CCAs; Yoklavich et al., 2007)
- ROV (So. CA Bight; Steirhoff et al., 2013)
- Nearshore rockfish (video lander & ROV, ongoing)





Tracking Abundance of Nearshore Stocks

- Traditional survey data not available for nearshore groundfish stocks
- Dockside sampling collects aggregated (trip-level) catch, effort, and location information
- Created relational databases for OR & CA onboard CPFV observer programs (Monk et al., 2013, in press)
- Analysis underway of drift-level data in relation to habitat data for state waters (Monk et al., in prep.) – improve distinction between structural, observational 0's.
- Consideration of nearshore survey methods and other datasets (CA MPA monitoring data, drop cameras, ROV)



Summary

Theme I: Scientific/technical approach to fishery stock assessment modeling

a) Is the Center using an appropriate suite of analytical methods to meet the regional fishery stock assessment objectives?

b) Does the suite of assessment models cover considerations from data-poor to data-rich?

c) Are assessments capable of considering possible ecosystem effects?

d) Does the Center work on enhancing and testing these analytical methods? Are they keeping with and contributing to the state-of-the-science nationally and internationally?

Strengths, Challenges, and Strategies

Strengths:

- Research guided by management needs, with equal emphasis on process studies
- Contributions to data-limited assessment methods (e.g. DCAC, DB-SRA, XDB-SRA)
- Research supporting assessments (e.g. rockfish recruitment index, abundance trends for nearshore species, reproductive biology, historical catch reconstruction, uncertainty in catch data)

Challenges:

- Staff size (4 FTEs focused on groundfish assessment research)
- Dependent on contractors for many mission-critical skills, e.g. data management, ageing, reproductive biology, GIS

Strategies:

- Continue to develop novel assessment methods for data-limited stocks
- Further explore sampling and analytical methods for estimating distribution and abundance of nearshore groundfish stocks
- Maintain progress on ecological studies (reproductive ecology, environmental influence on life history parameters, species interactions)